diffusion-fundamentals.org
The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Dependence of the relaxation time T_2 on a fluid flow velocity in a porous media

Valentin Loskutov

Mary State University, Yoshkar-Ola, Russia
Baker Hughes, Russian Science Center, Novosibirsk, Russia
val_losk@rambler.ru

Permeability is one of the key parameters describing the dynamic behavior of hydrocarbon-bearing reservoirs. Although proper prediction of the dynamic properties of a reservoir requires a detailed three-dimensional distribution of permeability, knowledge of this property along the well trajectory is most valuable also because the near-well bore region controls inflow performance. Permeability κ determines the flow rate caused by a pressure gradient, defined as follows [1]: $\kappa = \nu\eta/(dp/dx)$, where ν is fluid velocity, η is fluid viscosity, and dp/dx is the pressure gradient. Consequently, permeability can only be measured by means of a (dynamic) flow experiment. This is contrary to most other petrophysical properties such as porosity, saturation and lithology, which are static properties. Direct permeability determination requires a flow measurement. The challenge is to design such a methodology of measurement that can be done under normal logging condition. We analyze a possible approach for determining flow permeability using a combined NMR logging measurement in the presence of induced fluid flow.

The NMR relaxation rates are primarily controlled by the thermal motion of the fluid molecules and the collision of the fluid molecules with the internal surface of the pores in the rock. When fluid moves relative to the formation matrix the relaxation rate is augmented by velocity dependent terms. In [2] it was shown that the relaxation rate is proportional to the ν^2. However, a more rigorous analysis shows that this condition can be realized at high fluid flow velocities, and at sufficiently low flow velocity the relaxation time will be determined by the equation

$$\frac{1}{T_2} = \frac{1}{T_{2B}} + \frac{1}{T_{2D}} + \frac{4(\sqrt{2}-0.5)}{35}\gamma^2 G^2 \sqrt{D}\nu\tau^{5/2},$$

where first term T_{2B} is the contribution from the fluid bulk relaxation mechanism, the second term $1/T_{2D} = \gamma^2 G^2 \tau^2/12$, reflects the relaxation due to the self-diffusion of a liquid in the presence of a magnetic field gradient, G, where time τ refers to the time delay between the radio frequency pulse and the refocusing RF pulse in the spin echo pulse sequence and γ is the nuclear gyromagnetic ratio. The Fig. 1 shows the show the dependence of average relaxation rate $1/\langle T_2 \rangle$ on the fluid flow velocity. As can be seen from Fig. 1, the relaxation rate in the presented range of velocities of fluid flow is proportional to the flow velocity.

References

[1] D. Tiab, E.C. Donaldson: *Petrophysics, theory and practice of measuring rock and fluid transport properties*. Houston (TX): Gulf (1996)

[2] H. Thomann, R. Nielsen, M. Zhou: *Fluid flow properties from acoustically stimulated magnetic field gradient NMR*. SPWLA 47th Annual Logging Symposium, 2006.A

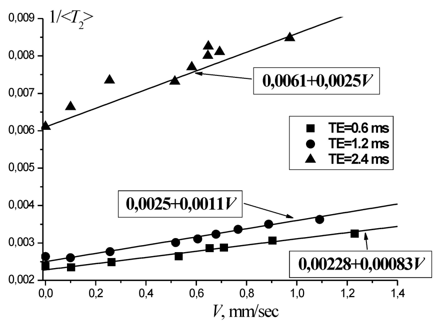

Figure 1: The dependence of the average relaxation rate $1/\langle T_2 \rangle$ on fluid flow velocity (Berea core).